

What is Claimed is:

1. A surface shape recognition sensor
2 comprising:
3 a plurality of capacitive detection elements
4 formed from lower electrodes and a deformable plate-like
5 upper electrode made of a metal, the lower electrodes
6 being insulated and isolated from each other and
7 stationarily laid out on a single plane of an interlevel
8 dielectric formed on a semiconductor substrate, and the
9 upper electrode being laid out above the lower
10 electrodes at a predetermined interval and having a
11 plurality of opening portions;
12 a support electrode laid out around the lower
13 electrodes while being insulated and isolated from the
14 lower electrodes, and formed to be higher than the lower
15 electrodes to support the upper electrode;
16 a protective film formed on the upper
17 electrode to close the opening portions; and
18 a plurality of projections laid out in a
19 region of said protective film above said capacitive
20 detection element.

2. A sensor according to claim 1, wherein said
2 protective film and projections are integrally formed.

3. A sensor according to claim 1, wherein said

2 support electrode is made of a metal.

4. A sensor according to claim 1, wherein
2 said sensor comprises an electrode dielectric
3 film laid out on the lower electrode, and
4 the upper electrode is laid out above said
5 electrode dielectric film at a predetermined interval.

5. A sensor according to claim 4, wherein
2 letting A be a moving amount of a central portion of the
3 upper electrode when the upper electrode deforms at
4 maximum within an elastic deformation range, the
5 interval between the upper electrode and said electrode
6 dielectric film is not more than A.

6. A sensor according to claim 4, wherein said
2 electrode dielectric film is formed into substantially
3 the same shape as that of the lower electrode and laid
4 out to cover the lower electrode.

7. A surface shape recognition sensor
2 comprising:
3 a plurality of capacitive detection elements
4 formed from lower electrodes and a deformable plate-like
5 upper electrode made of a metal, the lower electrodes
6 being insulated and isolated from each other and
7 stationarily laid out on a single plane of an interlevel

8 dielectric formed on a semiconductor substrate, and the
9 upper electrode being laid out above the lower
10 electrodes at a predetermined interval and having a
11 plurality of opening portions;

12 a support electrode laid out around the lower
13 electrodes while being insulated and isolated from the
14 lower electrodes, and formed to be higher than the lower
15 electrodes to support the upper electrode;

16 a protective film formed on the upper
17 electrode to close the opening portions; and

18 a projection made of a metal and laid out in a
19 region of said protective film above said capacitive
20 detection element.

8. A sensor according to claim 7, wherein said
2 projection is laid out in a region above the lower
3 electrode.

9. A sensor according to claim 7, wherein a
2 plurality of projections are laid out in the region
3 above said capacitive detection element.

10. A sensor according to claim 7, wherein said
2 support electrode is made of a metal.

11. A sensor according to claim 7, wherein
2 said sensor comprises an electrode dielectric

3 film laid out on the lower electrode, and
4 the upper electrode is laid out above said
5 electrode dielectric film at a predetermined interval.

12. A sensor according to claim 11, wherein
2 letting A be a moving amount of a central portion of the
3 upper electrode when the upper electrode deforms at
4 maximum within an elastic deformation range, the
5 interval between the upper electrode and said electrode
6 dielectric film is not more than A.

13. A sensor according to claim 11, wherein said
2 electrode dielectric film is formed into substantially
3 the same shape as that of the lower electrode and laid
4 out to cover the lower electrode.

14. A method of manufacturing a surface shape
2 recognition sensor, comprising the steps of:
3 forming an interlevel dielectric on a
4 semiconductor substrate;
5 forming a first metal film on the interlevel
6 dielectric;
7 forming a first mask pattern having an opening
8 portion in a predetermined region on the first metal
9 film;
10 forming a first metal pattern on a surface of
11 the first metal film exposed to a bottom portion of the

12 opening portion of the first mask pattern by plating;
13 after the first mask pattern is removed,
14 forming a second mask pattern having an opening portion
15 laid out around the first metal pattern on the first
16 metal film and first metal pattern;
17 forming a second metal pattern thicker than
18 the first metal pattern on the surface of the first
19 metal film exposed to a bottom portion of the opening
20 portion of the second mask pattern by plating;
21 after the second mask pattern is removed,
22 etching and removing the first metal film using the
23 first and second metal patterns as a mask to form a
24 lower electrode formed from the first metal film and
25 first metal pattern and a support electrode formed from
26 the first metal film and second metal pattern;
27 forming a sacrificial film on the interlevel
28 dielectric to cover the lower electrode while keeping an
29 upper portion of the support electrode exposed;
30 forming an upper electrode having a plurality
31 of opening portions on the sacrificial film and support
32 electrode;
33 after the upper electrode is formed,
34 selectively removing only the sacrificial film through
35 the opening portions;
36 after the sacrificial film is removed, forming
37 a protective film on the upper electrode;
38 forming a photosensitive resin film having

39 photosensitivity on the protective film; and
40 forming a plurality of projections in a region
41 of the protective film above a capacitive detection
42 element by exposing and developing a predetermined
43 pattern on the photosensitive resin film,
44 wherein a plurality of capacitive detection
45 elements each having the lower electrode and upper
46 electrode are formed.

15. A method according to claim 14, wherein the
2 protective film is formed on the upper electrode by
3 transfer.

16. A method according to claim 15, wherein in
2 the protective film transfer step, STP is used as a
3 transfer method.

17. A method according to claim 15, wherein
2 the lower electrode formation step comprises
3 the steps of forming the first metal film on the
4 semiconductor substrate, forming a first patterned
5 resist on the first metal film, forming the lower
6 electrode in an opening portion of the first resist, and
7 removing the first resist,
8 the support electrode formation step comprises
9 the steps of forming a second patterned resist on the
10 first metal film, forming the support electrode in an

11 opening portion of the second resist, removing the
 12 second resist, and etching the first metal film using
 13 the lower electrode and support electrode as a mask,
 14 the upper electrode formation step comprises
 15 the steps of forming the sacrificial film on the lower
 16 electrode and support electrode, removing the
 17 sacrificial film on the support electrode to expose the
 18 support electrode, forming a second metal film on the
 19 support electrode and sacrificial film, forming a third
 20 patterned resist on the second metal film, forming the
 21 upper electrode in an opening portion of the third
 22 resist, removing the third resist, etching the second
 23 metal film using the upper electrode as a mask, and
 24 removing the sacrificial film,
 25 the protective film transfer step comprises
 26 the step of transferring the protective film onto the
 27 upper electrode by STP,
 28 the photosensitive resin film formation step
 29 comprises the step of applying the photosensitive resin
 30 film onto the protective film, and
 31 the step of fabricating the photosensitive
 32 resin film into the projections comprises the steps of
 33 exposing part of the photosensitive resin film and
 34 executing development after exposure.

18. A method according to claim 14, wherein the
 2 sacrificial film is essentially formed from a polyimide

3 resin.

19. A method according to claim 14, wherein the
2 sacrificial film is essentially formed from a
3 polybenzoxazole precursor resin.

20. A method according to claim 14, wherein the
2 sacrificial film is removed by heating the sacrificial
3 film and simultaneously exposing the sacrificial film to
4 an ozone ambient.

21. A method according to claim 14, wherein the
2 lower electrode, support electrode, and upper electrode
3 are essentially formed from gold.

22. A method according to claim 14, wherein
2 the upper electrode is formed on the
3 sacrificial film and support electrode while separating
4 the opening portions from a side wall of the support
5 electrode, and
6 after the sacrificial film is removed, a
7 liquid material is applied onto the upper electrode to
8 form a coat, and the coat is hardened to form the
9 protective film on the upper electrode to close the
10 opening portions.

23. A method according to claim 22, wherein in

2 forming the coat, the coat is laid out on a force acting
3 side of the substrate and hardened.

24. A method according to claim 23, wherein in
2 forming the coat, the coat is laid out on a lower side
3 of the substrate and hardened.

25. A method according to claim 22, wherein
2 letting t be a thickness of the coat in a
3 region other than the opening portions in forming the
4 coat,
5 a be a sectional area of the opening portion
6 at a boundary between the opening portion and an
7 external portion of a space formed between the upper
8 electrode and the lower electrode,
9 b be a peripheral length of a section of the
10 opening portion at a boundary between the space and the
11 opening portion,
12 c be a volume in the opening portion,
13 d be the magnitude of surface tension, at the
14 boundary between the space and the opening portion,
15 between an opening portion inner wall and a portion of
16 the coat that has entered the opening portion,
17 e be a density of the coat, and
18 g be a gravitational acceleration,
19 a relationship given by
20
$$(c + a \times t) \times e \times g \leq b \times d$$

21 is satisfied.

26. A method according to claim 22, wherein
2 the upper electrode is formed by plating gold
3 on and around the sacrificial film, and
4 the coat is formed by applying the liquid
5 material formed from polyimide.

27. A method according to claim 26, wherein
2 the coat is formed by applying the liquid
3 material formed from polyimide having photosensitivity,
4 and
5 the protective film is formed in an opening
6 portion region on the upper electrode to close the
7 opening portions by removing a region of the coat other
8 than a peripheral region of the opening portions by
9 photolithography and hardening a remaining portion.

28. A method according to claim 14, wherein
2 before the sacrificial film is formed,
3 a first dielectric film that is lower than the
4 support electrode and covers the lower electrode is
5 formed on the lower electrode, and
6 the first dielectric film is selectively
7 removed to form an electrode dielectric film on the
8 lower electrode.

29. A method according to claim 14, wherein

2 after the first metal pattern is formed,

3 a first dielectric film is formed on the first
4 metal pattern to cover the first metal pattern,

5 the first mask pattern is removed to form an
6 electrode dielectric film on the first metal pattern,
7 and then,

8 the second mask pattern is formed.

30. A method according to claim 14, wherein

2 after the first mask pattern is removed, a
3 first dielectric film is formed on the first metal
4 pattern to cover the first metal pattern,

5 the first dielectric film is selectively
6 removed to form an electrode dielectric film on the
7 first metal pattern, and

8 after the electrode dielectric film is formed,
9 the second mask pattern is formed.

31. A method of manufacturing a surface shape

2 recognition sensor, comprising the steps of:

3 forming an interlevel dielectric on a
4 semiconductor substrate;

5 forming a first metal film on the interlevel
6 dielectric;

7 forming a first mask pattern having an opening
8 portion in a predetermined region on the first metal

9 film;

10 forming a first metal pattern on a surface of
11 the first metal film exposed to a bottom portion of the
12 opening portion of the first mask pattern by plating;

13 after the first mask pattern is removed,
14 forming a second mask pattern having an opening portion
15 laid out around the first metal pattern on the first
16 metal film and first metal pattern;

17 forming a second metal pattern thicker than
18 the first metal pattern on the surface of the first
19 metal film exposed to a bottom portion of the opening
20 portion of the second mask pattern by plating;

21 after the second mask pattern is removed,
22 etching and removing the first metal film using the
23 first and second metal patterns as a mask to form a
24 lower electrode formed from the first metal film and
25 first metal pattern and a support electrode formed from
26 the first metal film and second metal pattern;

27 forming a sacrificial film on the interlevel
28 dielectric to cover the lower electrode while keeping an
29 upper portion of the support electrode exposed;

30 forming an upper electrode having a plurality
31 of opening portions on the sacrificial film and support
32 electrode;

33 after the upper electrode is formed,
34 selectively removing only the sacrificial film through
35 the opening portions;

36 after the sacrificial film is removed, forming
 37 a photosensitive resin film having photosensitivity on
 38 the upper electrode; and
 39 simultaneously forming a protective film that
 40 covers the upper electrode and a plurality of
 41 projections laid out in a region of the protective film
 42 above a capacitive detection element by exposing and
 43 developing a predetermined pattern on the photosensitive
 44 resin film,
 45 wherein a plurality of capacitive detection
 46 elements each having the lower electrode and upper
 47 electrode are formed.

32. A method according to claim 31, wherein the
 2 photosensitive resin film is formed on the upper
 3 electrode by transfer.

33. A method according to claim 32, wherein in
 2 the photosensitive resin film transfer step, STP is used
 3 as a transfer method.

34. A method according to claim 32, wherein
 2 the lower electrode formation step comprises
 3 the steps of forming the first metal film on the
 4 semiconductor substrate, forming a first patterned
 5 resist on the first metal film, forming the lower
 6 electrode in an opening portion of the first resist, and

7 removing the first resist,

8 the support electrode formation step comprises
9 the steps of forming a second patterned resist on the
10 first metal film, forming the support electrode in an
11 opening portion of the second resist, removing the
12 second resist, and etching the first metal film using
13 the lower electrode and support electrode as a mask,

14 the upper electrode formation step comprises
15 the steps of forming the sacrificial film on the lower
16 electrode and support electrode, removing the
17 sacrificial film on the support electrode to expose the
18 support electrode, forming a second metal film on the
19 support electrode and sacrificial film, forming a third
20 patterned resist on the second metal film, forming the
21 upper electrode in an opening portion of the third
22 resist, removing the third resist, etching the second
23 metal film using the upper electrode as a mask, and
24 removing the sacrificial film,

25 the photosensitive resin film transfer step
26 comprises the step of transferring the photosensitive
27 resin film onto the upper electrode by STP, and

28 the step of forming the protective film and
29 the plurality of projections on the protective film
30 comprises the steps of exposing part of the
31 photosensitive resin film and executing development
32 after exposure.

35. A method according to claim 31, wherein the
2 sacrificial film is essentially formed from a polyimide
3 resin.

36. A method according to claim 31, wherein the
2 sacrificial film is essentially formed from a
3 polybenzoxazole precursor resin.

37. A method according to claim 31, wherein the
2 sacrificial film is removed by heating the sacrificial
3 film and simultaneously exposing the sacrificial film to
4 an ozone ambient.

38. A method according to claim 31, wherein the
2 lower electrode, support electrode, and upper electrode
3 are essentially formed from gold.

39. A method according to claim 31, wherein
2 before the sacrificial film is formed,
3 a first dielectric film that is lower than the
4 support electrode and covers the lower electrode is
5 formed on the lower electrode, and
6 the first dielectric film is selectively
7 removed to form an electrode dielectric film on the
8 lower electrode.

40. A method according to claim 31, wherein

2 after the first metal pattern is formed,
3 a first dielectric film is formed on the first
4 metal pattern to cover the first metal pattern,
5 the first mask pattern is removed to form an
6 electrode dielectric film on the first metal pattern,
7 and then,
8 the second mask pattern is formed.

41. A method according to claim 31, wherein
2 after the first mask pattern is removed, a
3 first dielectric film is formed on the first metal
4 pattern to cover the first metal pattern,
5 the first dielectric film is selectively
6 removed to form an electrode dielectric film on the
7 first metal pattern, and
8 after the electrode dielectric film is formed,
9 the second mask pattern is formed.

42. A method of manufacturing a surface shape
2 recognition sensor, comprising the steps of:
3 forming an interlevel dielectric on a
4 semiconductor substrate;
5 forming a first metal film on the interlevel
6 dielectric;
7 forming a first mask pattern having an opening
8 portion in a predetermined region on the first metal
9 film;

10 forming a first metal pattern on a surface of
 11 the first metal film exposed to a bottom portion of the
 12 opening portion of the first mask pattern by plating;
 13 after the first mask pattern is removed,
 14 forming a second mask pattern having an opening portion
 15 laid out around the first metal pattern on the first
 16 metal film and first metal pattern;
 17 forming a second metal pattern thicker than
 18 the first metal pattern on the surface of the first
 19 metal film exposed to a bottom portion of the opening
 20 portion of the second mask pattern by plating;
 21 after the second mask pattern is removed,
 22 etching and removing the first metal film using the
 23 first and second metal patterns as a mask to form a
 24 lower electrode formed from the first metal film and
 25 first metal pattern and a support electrode formed from
 26 the first metal film and second metal pattern;
 27 forming a sacrificial film on the interlevel
 28 dielectric to cover the lower electrode while keeping an
 29 upper portion of the support electrode exposed;
 30 forming an upper electrode having a plurality
 31 of opening portions on the sacrificial film and support
 32 electrode;
 33 after the upper electrode is formed,
 34 selectively removing only the sacrificial film through
 35 the opening portions;
 36 after the sacrificial film is removed, forming

37 a protective film on the upper electrode;
38 forming a second metal film on the protective
39 film;
40 forming a third mask pattern having an opening
41 portion in a predetermined region on the second metal
42 film;
43 forming a third metal pattern on a surface of
44 the second metal film exposed to a bottom portion of the
45 opening portion of the third mask pattern by plating;
46 and
47 after the third mask pattern is removed,
48 etching and removing the second metal film using the
49 third metal pattern as a mask to form a projection
50 formed from the second metal film and third metal
51 pattern
52 wherein a plurality of capacitive detection
53 elements each having the lower electrode and upper
54 electrode are formed.

43. A method according to claim 42, wherein the
2 protective film is formed on the upper electrode by
3 transfer.

44. A method according to claim 43, wherein in
2 the protective film transfer step, STP is used as a
3 transfer method.

45. A method according to claim 42, wherein the
2 sacrificial film is essentially formed from a polyimide
3 resin.

46. A method according to claim 42, wherein the
2 sacrificial film is essentially formed from a
3 polybenzoxazole precursor resin.

47. A method according to claim 42, wherein the
2 sacrificial film is removed by heating the sacrificial
3 film and simultaneously exposing the sacrificial film to
4 an ozone ambient.

48. A method according to claim 42, wherein the
2 lower electrode, support electrode, and upper electrode
3 are essentially formed from gold.

49. A method according to claim 42, wherein
2 the upper electrode is formed on the
3 sacrificial film and support electrode while separating
4 the opening portions from a side wall of the support
5 electrode, and
6 after the sacrificial film is removed, a
7 liquid material is applied onto the upper electrode to
8 form a coat, and the coat is hardened to form the
9 protective film on the upper electrode to close the
10 opening portions.

50. A method according to claim 49, wherein in
2 forming the coat, the coat is laid out on a force acting
3 side of the substrate and hardened.

51. A method according to claim 50, wherein in
2 forming the coat, the coat is laid out on a lower side
3 of the substrate and hardened.

52. A method according to claim 49, wherein
2 letting t be a thickness of the coat in a
3 region other than the opening portions in forming the
4 coat,
5 a be a sectional area of the opening portion
6 at a boundary between the opening portion and an
7 external portion of a space formed between the upper
8 electrode and the lower electrode,
9 b be a peripheral length of a section of the
10 opening portion at a boundary between the space and the
11 opening portion,
12 c be a volume in the opening portion,
13 d be the magnitude of surface tension, at the
14 boundary between the space and the opening portion,
15 between an opening portion inner wall and a portion of
16 the coat that has entered the opening portion,
17 e be a density of the coat, and
18 g be a gravitational acceleration,

19 a relationship given by
20 $(c + a \times t) \times e \times g \leq b \times d$
21 is satisfied.

53. A method according to claim 49, wherein
2 the upper electrode is formed by plating gold
3 on and around the sacrificial film, and
4 the coat is formed by applying the liquid
5 material formed from polyimide.

54. A method according to claim 53, wherein
2 the coat is formed by applying the liquid
3 material formed from polyimide having photosensitivity,
4 and
5 the protective film is formed in an opening
6 portion region on the upper electrode to close the
7 opening portions by removing a region of the coat other
8 than a peripheral region of the opening portions by
9 photolithography and hardening a remaining portion.

55. A method according to claim 42, wherein
2 before the sacrificial film is formed,
3 a first dielectric film that is lower than the
4 support electrode and covers the lower electrode is
5 formed on the lower electrode, and
6 the first dielectric film is selectively
7 removed to form an electrode dielectric film on the

8 lower electrode.

56. A method according to claim 42, wherein
2 after the first metal pattern is formed,
3 a first dielectric film is formed on the first
4 metal pattern to cover the first metal pattern,
5 the first mask pattern is removed to form an
6 electrode dielectric film on the first metal pattern,
7 and then,
8 the second mask pattern is formed.

57. A method according to claim 42, wherein
2 after the first mask pattern is removed, a
3 first dielectric film is formed on the first metal
4 pattern to cover the first metal pattern,
5 the first dielectric film is selectively
6 removed to form an electrode dielectric film on the
7 first metal pattern, and
8 after the electrode dielectric film is formed,
9 the second mask pattern is formed.